## REMARKS

Favorable reconsideration and allowance of the claims of the present application are respectfully requested.

Before addressing the various substantive grounds of rejection raised in the outstanding Office Action, Applicants have amended dependent Claim 21 so that the claim now depends on independent Claim 15. This amendment resolves the dependency of original Claim 21 on cancelled Claim 20. Also, Claims 25 – 30 have been cancelled without prejudice.

Since the above amendments to the claims pertain only to formal matters, entry thereof is respectfully requested.

In the outstanding Office Action, Claims 1-7, 9-10, 12-14, 15-19, 22 and 23-25 stand rejected under 35 U.S.C. § 102(b) as allegedly anticipated by U.S. Patent No. 6,413,859 to Cabral, Jr. et al., ("Cabral, Jr."). Claims 8, 11, 20, 21 and 23 stand rejected under 35 U.S.C. § 103 as allegedly unpatentable over the disclosure of Cabral, Jr.

With respect to the § 102(b) rejection, it is axiomatic that anticipation under § 102 requires that the prior art reference disclose each and every element of the claim to which it is applied. In re King, 801 F.2d, 1324, 1326, 231 USPQ 136, 138 (Fed. Cir. 1986). Thus, there must be no differences between the subject matter of the claim and the disclosure of the prior art reference. Stated another way, the reference must contain within its four corners adequate direction to practice the invention as claimed. The corollary of the rule is equally applicable: Absence from the applied reference of any claimed element negates anticipation. Kloster Speedsteel AB v. Crucible Inc., 793 F.2d 1565, 1571, 230 USPQ 81, 84 (Fed. Cir. 1986).

Applicants respectfully submit that the claimed methods, as recited in Claims 1-7, 9–10, 12-19 and 21-25 of the present application, are not anticipated by the disclosure of Cabral, Jr.

Specifically, Cabral, Jr. does not disclose a method of forming a metal silicide (including a Co disilicide) which includes, among the other recited processing steps, a step of subjecting a structure comprising a metal-containing (or Co-containing) silicon alloy layer over a Si-containing material to a first anneal which comprises a first thermal cycle which is performed at a first temperature of less than about 350°C that enhances ***uni-directional diffusion of said metal (or Co)*** into said Si-containing material thereby forming an amorphous metal-containing (or Co-containing) silicide and a second thermal cycle which is performed at a second temperature that converts the amorphous metal-containing (or Co-containing) silicide into a crystallized metal (or Co) rich silicide that is substantially non-etchable as compared to the metal-containing (or Co-containing) silicon alloy layer.

Applicants submit that the process of silicide formation and the resulting silicide structure as they are disclosed and claimed in the present application are substantially different from those disclosed by Cabral Jr. and that the methods of silicide formation as disclosed and claimed in the present application could not have been anticipated by the disclosures of Cabral. Jr.

Firstly, this is because the amount of oxygen at the interface significantly affects the silicide formation process. Quoting a passage in the introduction section of an article by Lavoie et al, "Effects of Alloying Elements on Cobalt Silicide Formation,"[1] states that "[S]uccessful formation of cobalt silicide now relies now on a thin suboxide at the Si/Co interface that affects the diffusion during annealing sufficiently to limit the epitaxial faceting between the silicon and the disilicide, and limit the interface roughness." This statement indicates that the development

[1] NSLS Activity Report 2001, a copy which is enclosed.

of silicide formation in the semiconductor industry has now reached a point where the role of interfacial oxide affects the quality of the silicide. According to the present application, the low temperature of less than about 350°C is necessary to insure that ***uni-directional*** diffusion of metal is enhanced. However, according to the prior art that utilizes higher temperature for a pre-anneal, or the first temperature cycling in the first anneal, this temperature is between 350°C and 450°C. As stated at page 1, lines 27 – 29 through page 2, lines 1 – 6, the prior art induces bi-lateral diffusion of both metal and silicon. Quoting these paragraph, "[D]espite being able to form metal silicide contacts, the self-aligned silicide process mentioned above has several problems associated therewith. In particular, in the conventional silicide process mentioned above, both the metal, e.g., Co, and Si interdiffuse through a thin oxide. This bi-lateral diffusion is illustrated in FIG. 1A, wherein reference numeral 10 is a Si-containing material, reference numeral 12 is a Co layer, reference numeral 14 designated by the broken line is a native oxide layer, reference numeral 16 shows the direction of Si diffusion, and reference numeral 18 shows the direction of Co diffusion. As is shown, the Si diffuses up, while the Co diffuses down in the conventional self-aligned silicide process." Page 6, lines 8 – 10 specifies "[I]n accordance with the present invention, the first thermal cycle of the first anneal is performed at a temperature that is capable of enhancing the uni-directional diffusion of a refractory metal, such as Co, Ni or Co and Ni, into a Si-containing layer." In other words, the limitation of a low temperature of less than about 350°C is introduced because the present invention requires an enhancement of ***uni-directional*** diffusion of metal during the first thermal cycling of the first anneal. The feature or even the concept of enhancing uni-directional diffusion of metal during the first thermal cycling of the first metal is an essential feature of the claimed invention, but is not disclosed in Cabral Jr.

Secondly, the composition and properties of silicides depend critically on the anneal temperature. Such critical dependence of the structure and properties of metal silicide on the temperature at which silicide is annealed is well known in the industry. For example, a web page printout as of October 18, 2006 from the web site, http://www.stanford.edu/class/ee311/, shows that the grain size changes substantially in silicides.[2] Specifically, the section on *Effect of Thermal Processing on Silicide Properties* in page 7 states "[I]n all the silicide formation schemes detailed above, it is usually necessary to subject the silicide to further thermal processing, either to form the silicide or enhance the grain size. In particular, for CVD and deposited silicides (as opposed to thermally formed silicides), grain size can be enhanced substantially by annealing." The same section also states "[H]igher temperature and longer time gives bigger grains and thus lower resistivity." Four TEM pictures demonstrate the dramatic impact that the annealing temperature has on the grain size of tungsten silicide, which also applies to all silicides and to cobalt silicide as well. In addition, the resistivity and the composition of silicide changes with the anneal temperature, or "sintering temperature." Specifically, the table on page 3 of the aforementioned web page printout shows that within the temperature range between 300°C to 500°C, $Co_2Si$ is formed and within the temperature range between 400°C to 600°C, CoSi is formed. In accordance with the disclosure of Cabral, Jr., a pre-anneal step that is performed at a temperature of about 350°C to 450°C prior to the main anneal and therefore, the composition of cobalt silicide encompasses $Co_2Si$ and CoSi. According to the present invention, a first thermal cycle in a first anneal is performed at a first temperature of less than about 350°C, which produces only $Co_2Si$. Therefore, one of ordinary skill in the art would expect a different silicide structure after an anneal at a temperature below about 350°C compared

[2] A copy of this web page is also enclosed herewith.

to a corresponding silicide structure after an anneal within the temperature range between 350°C to 450°C.

Due to the lack of any discussion in Cabral Jr. on uni-directional diffusion of metal, it is impossible for one of ordinary skill in the art to construct methods of inducing a uni-directional diffusion of metal for the purpose of silicide formation from the disclosure of Cabral Jr.

The foregoing remarks clearly demonstrate that the applied reference does not teach each and every aspect of the claimed invention, as required by King and Kloster Speedsteel; therefore, the claims of the present application are not anticipated by the disclosure of Cabral, Jr. Applicants respectfully submit that the instant § 102 rejection has been obviated and withdrawal thereof is respectfully requested.

With respect to the obviousness rejection citing Cabral, Jr. Applicants respectfully submit that the applied reference does not teach or suggest Applicants' claimed methods as recited in Claims 1-7, 9–10, 12-19 and 21-25 of the present application.

As discussed above, Cabral, Jr. discloses a method wherein higher annealing temperatures are used in the first thermal cycle. The higher annealing temperatures recited in Cabral, Jr. do not provide enhanced ***uni-directional diffusion of said metal (or Co)*** into a Si-containing material thereby forming an amorphous metal-containing (or Co-containing) silicide, as presently claimed. Instead, in the prior art, the higher annealing temperatures are used to form a specific crystal phase of a silicide.

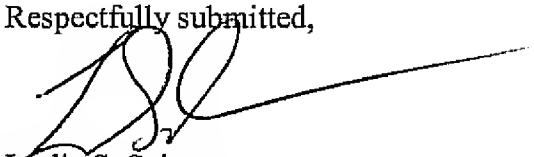
The § 103 rejection also fails because there is no motivation in the applied reference which suggests modifying the disclosed method to include the various features recited in the claims of the present invention. Stated in a different way, if Cabral does not discuss the concept of uni-directional diffusion of metal, there cannot be a motivation to enable a uni-directional

diffusion of metal in Cabral, Jr. Thus, there is no motivation provided in the applied reference, or otherwise of record, to make the modification mentioned above. "The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." In re Vaeck, 947 F.2d, 488, 493, 20 USPQ 2d. 1438, 1442 (Fed.Cir. 1991).

The rejection under 35 U.S.C. § 103 citing Cabral, Jr. has been obviated; therefore reconsideration and withdrawal thereof is respectfully requested.

In view of the above amendments and remarks, it is firmly believed that the present application is in condition for allowance, which action is earnestly solicited.

Respectfully submitted,



Leslie S. Szivos
Registration No. 39,394

SCULLY, SCOTT, MURPHY & PRESSER, P.C.
400 Garden City Plaza, Suite 300
Garden City, New York 11530
(516) 742-4343

**Customer No.: 23389**
LSS:BP:tam